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PERFORMANCE EVALUATION OF GRAIN SAMPLE DIVIDERS

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PERFORMANCE EVALUATION OF GRAIN SAMPLE DIVIDERS

By

C.A. Watson, Arvid L. Hawk, Dan Niffenegger, and Dean Duncan[1]

BACKGROUND

The normal procedure for mechanically sampling a lot of grain is to draw increment samples from the grain stream as the lot is being transferred from one location to another. These increments are combined to make a composite sample for analysis. The probability of drawing a representative sample from a lot increases as the number of increments is increased. There are practical limitations to the minimum size of these increment samples and for this reason the composite samples are usually larger than is feasible for a sample analysis.

Diverter-type mechanical samplers that remove increment samples from a grain stream at predetermined intervals are now available commercially. These primary samplers, when properly installed and operated, are capable of drawing representative samples from heterogeneous lots of grain. However, the composite primary samples are nearly always larger than are desired for analysis, so that only part of this amount is used.

Mechanical secondary sample dividers are used to reduce the size of samples drawn by diverter-type mechanical samplers. The smaller sample, however, is usually less representative of the lot than the entire sample. In addition, the design of the secondary sample divider may cause a bias in the smaller sample.

The mechanical secondary sample dividers are an integral and necessary part to a system for sampling grain using diverter-type mechanical samplers. These mechanical systems are rapidly being installed by the grain industry and information is needed on the performance and accuracy of the secondary sample dividers. The accuracy of the sample analyzed depends upon the accuracy of both the primary sampler and the secondary sample divider.

OBJECTIVE

The objective of this research was to determine the ability of several designs of secondary sample dividers to remove representative samples of grain from larger samples of grain of varying sizes and known composition.

PROCEDURE

GRAIN LOTS

The kinds of grains and levels of admixture components added to each were as follows:

1. Wheat lot: Wheat, 90 percent; corn, 5 percent; screenings, 5 percent.
2. Corn lot: Corn, 95 percent; wheat, 5 percent.

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[1] Leader, Grain Quality and Sampling Investigations, Market Quality Research Division, Agricultural Research Service, U.S. Department of Agriculture, Manhattan, Kans.; research engineer, Grain Research Laboratory, Cargill, Inc., Minneapolis, Minn.; assistant director, Biometrical Services Staff, Agricultural Research Service, Beltsville, Md.; and grain inspector, Grain Division, Consumer and Marketing Service, Minneapolis, Minn., respectively. Harold A. Kramer (retired) participated in the early planning and analysis.

3. Soybean lot: Soybeans, 95 percent, screenings, 5 percent.

These mixtures were chosen because a rapid and accurate laboratory analysis technique has been developed for them.[2]

SAMPLING PROCEDURE

Mechanical-Type Secondary Sample Dividers

The mechanical-type secondary sample dividers evaluated were the Gamet 7½-inch, series 4250, laboratory rotary divider, and the Gamet 12-inch, series 4500, 3-way rotary divider, both supplied by the Dean Gamet Manufacturing Company, Minneapolis, Minn.; the Denver 15-inch Vezin, Model 1, supplied by the Denver Equipment Company, Denver, Colo.; and the Strand, supplied by the Carter-Day Company, Minneapolis, Minn.

The Gamet secondary sample divider uses a rotating cylinder divided into compartments to divide a stream of grain for sampling (fig. 1). The cylinder rotates like a wheel in the vertical plane, is hollow, and has compartments around the inner rim. As the stream of grain falls into the cylinder, the rotation of the cylinder causes each compartment in turn to move through the stream of grain. Each compartment has an opening to an external chamber. The number of compartments opening into any one external chamber determines the percentage of the total sample routed through that chamber. Each of the external chambers is spouted to an individual sample collector.

The principle of the Gamet 7½-inch and the 12-inch rotary sample dividers is the same. The main difference is in the size of the rotary, 7½-inches and 12-inches, respectively. The 7½-inch rotary can be supplied to provide for two or three samples, and a minimum of one-tenth of the total input material can be obtained in each sample. The 12-inch type provides for two samples and a minimum of one-twelfth of the input material.

The weights of the input sample and the size of the feeder orifice used with the 7½-inch Gamet are shown in table 1. Also, the number of output samples and the approximate weight of each output sample are shown. An input sample weight of 10,000 grams was not used because the divider is not designed to take samples this large. Three output samples were obtained regardless of the size of the input sample. The sizes of the output samples were sample *a*, 1/10; sample *b*, 4/10; and sample *c*, 5/10; respectively, the weight of the input sample.

Weights of input samples and the sizes of the feeder orifices used with the Gamet 12-inch are shown in table 2. To obtain the output samples as shown in table 2, a series of dividers were used. The flow diagram used was that recommended by the manufacturer (fig. 2).

The Denver 15-inch Vezin secondary sample divider uses a truncated wedge of a circle (cutter) which rotates through the main stream of grain once every revolution (fig. 3). The model evaluated in this work (model 1) has one cutter and provides a 40:1 division of the grain.

The weights of the input samples, sizes of feeder orifices, and the number and approximate weight of each output sample for the Denver 15-inch Vezin is shown in table 3.

The Strand secondary sample divider uses a cylinder rotating in the horizontal plane (fig. 4). This cylinder rotates above four spouts of equal dimensions. As the stream of grain is discharged through the rotating cylinder, four samples of equal size are diverted through the four spouts. The speed at which the cylinder rotates can be varied. In this work, speeds used were 60 and 120 revolutions per minute (r.p.m.).

The weights of input samples, sizes of feeder orifices, and number and approximate weight of each output sample for the Strand is shown in table 4.

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[2] Kramer, H. A. Sampling of Wheat, Soybeans, and Corn Transported in Covered Hopper Cars. U.S. Dept. Agr., Agr. Res. Serv., ARS 51-20, 37 pp. 1968.

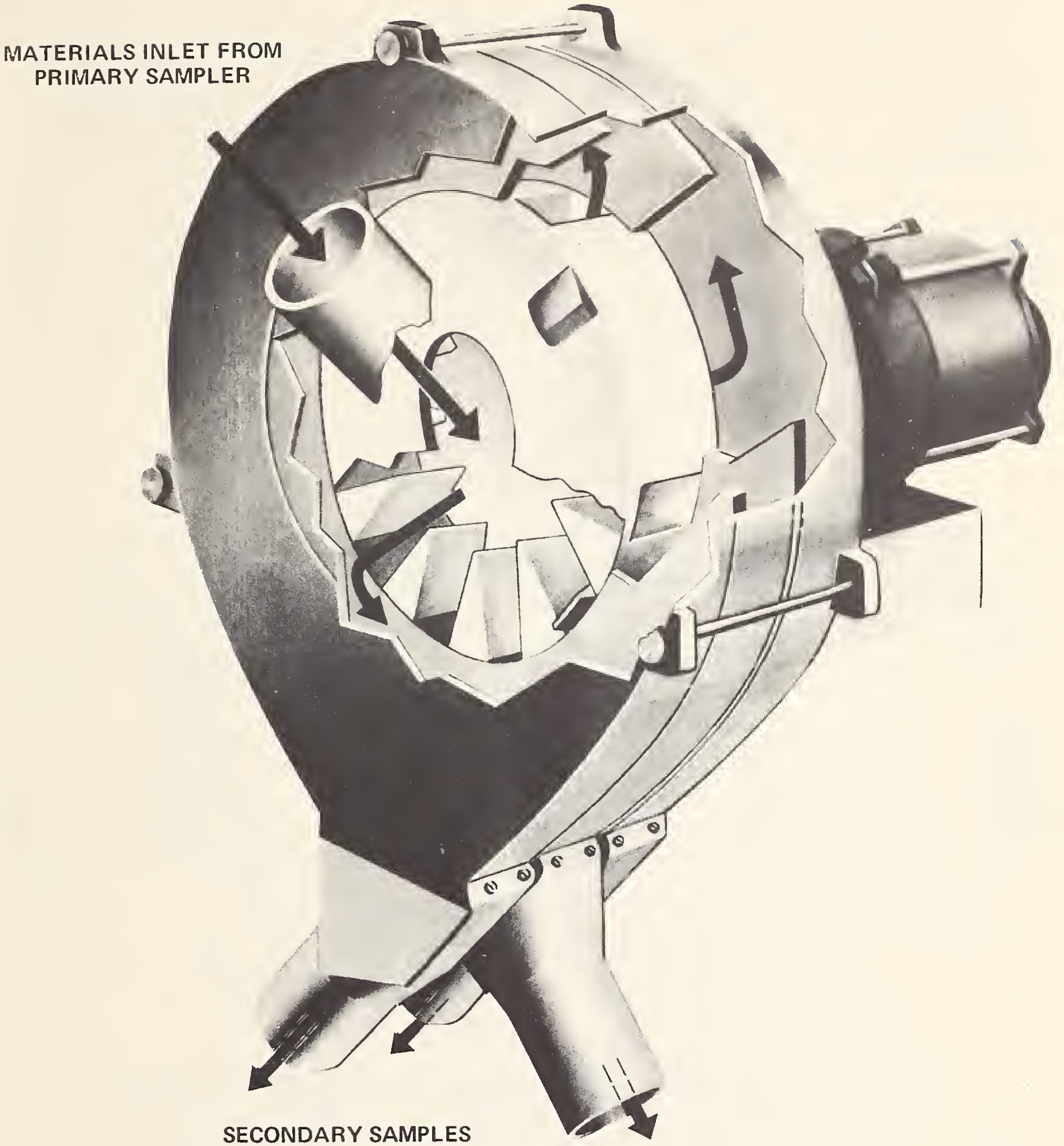


Figure 1.–Cutaway of a Gamet rotary secondary sample divider.

TABLE 1.—Weights of input samples, sizes of feeder orifices, number of output samples, and approximate weight of each output sample for the Gamet 7½-inch secondary sample divider

Weight of input sample (grams)	Size of feeder orifice	Output samples			
		Number	Approximate weight of each		
			a	b	c
	Inches		Grams	Grams	Grams
5,000	1½	3	500	2,000	2,500
2,500	1½	3	250	1,000	1,250
1,000	1½	3	100	400	500
500	1½	3	50	200	250

TABLE 2.—Weights of input samples, sizes of feeder orifices, number of output samples, and approximate weight of each output sample for the Gamet 12-inch secondary sample divider

Weight of input sample (grams)	Size of feeder orifice	Output samples[1]			
		Number	Approximate weight of each		
			a	b	c
	Inches		Grams	Grams	Grams
10,000	2¼	3	112	112	112
5,000	2¼	3	60	60	60
5,000	1½	3	100	100	100
2,500	1½	3	52	52	52
1,000	1½	3	55	55	55
500	1½	3	28	28	28

[1] Rest of input sample rejected.

TABLE 3.—Weights of input samples, sizes of feeder orifices, and number and approximate weight of each output sample for the Denver 15-inch Vezin secondary sample divider

Weight of input sample (grams)	Size of feeder orifice	Output samples[1]			
		Number	Approximate weight of each		
			Wheat lot	Corn lot	Soybean lot
	Inches		Grams	Grams	Grams
10,000	2 1/4	1	246	181	241
5,000	2 1/4	1	137	112	115
5,000	1 3/8	1	140	136	133
2,500	1 3/8	1	70	66	67
1,000	1 3/8	1	29	24	23
500	1 3/8	1	20	11	14

[1] Rest of each input sample rejected.

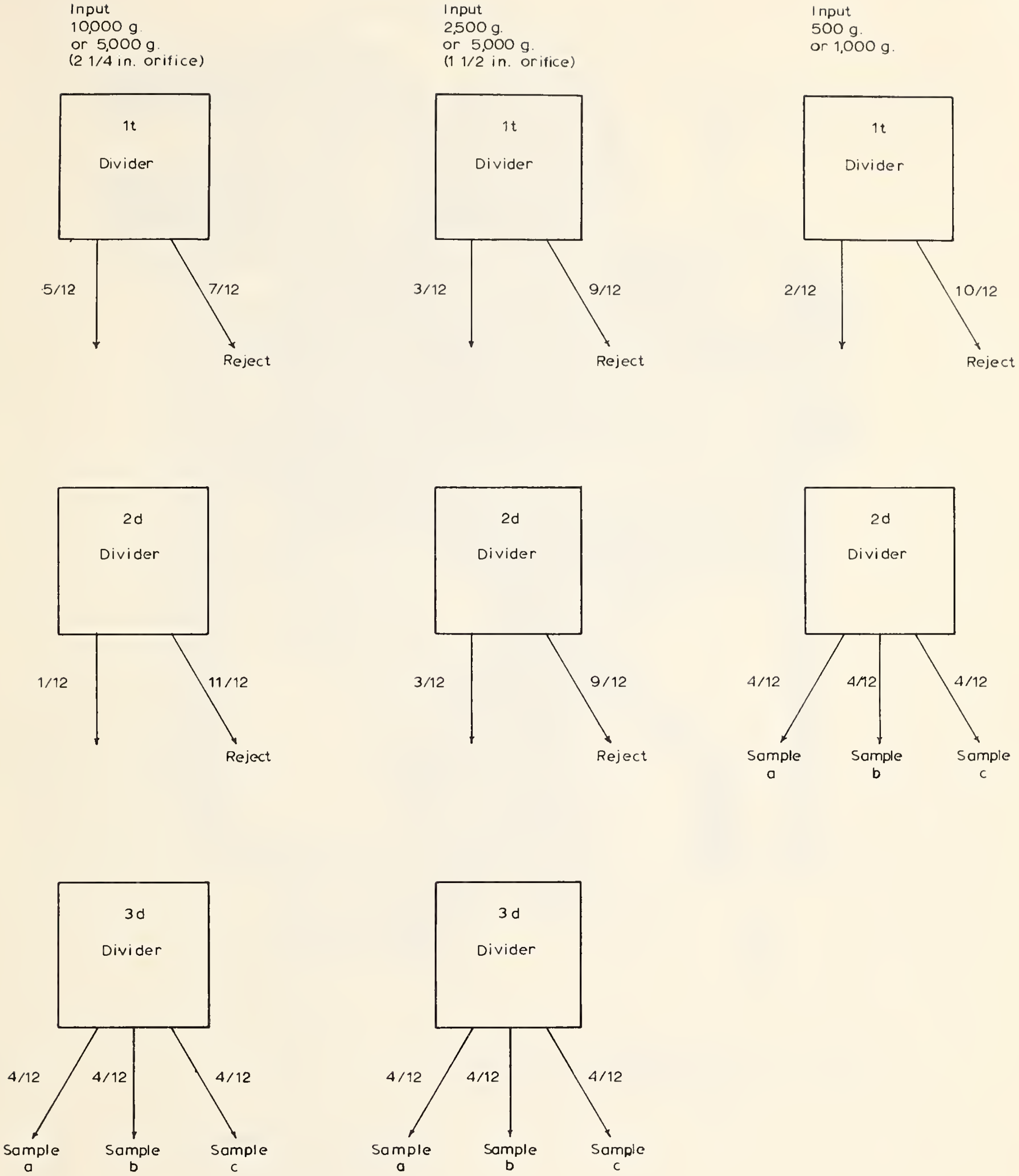


Figure 2.—Flow diagram used with the Gamet 12-inch rotary secondary sample divider.

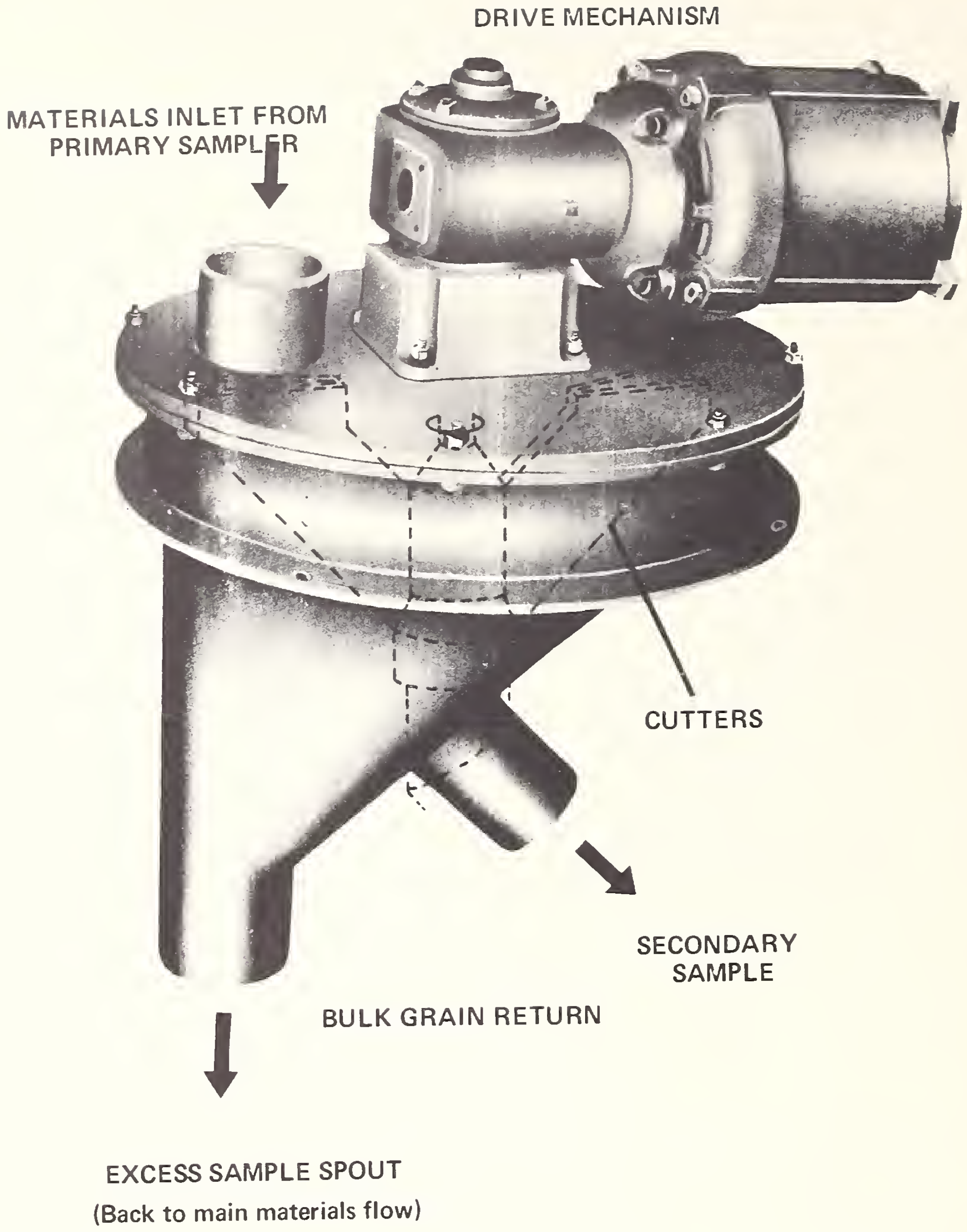


Figure 3.—Cutaway of a Denver Vezin-type secondary sample divider.

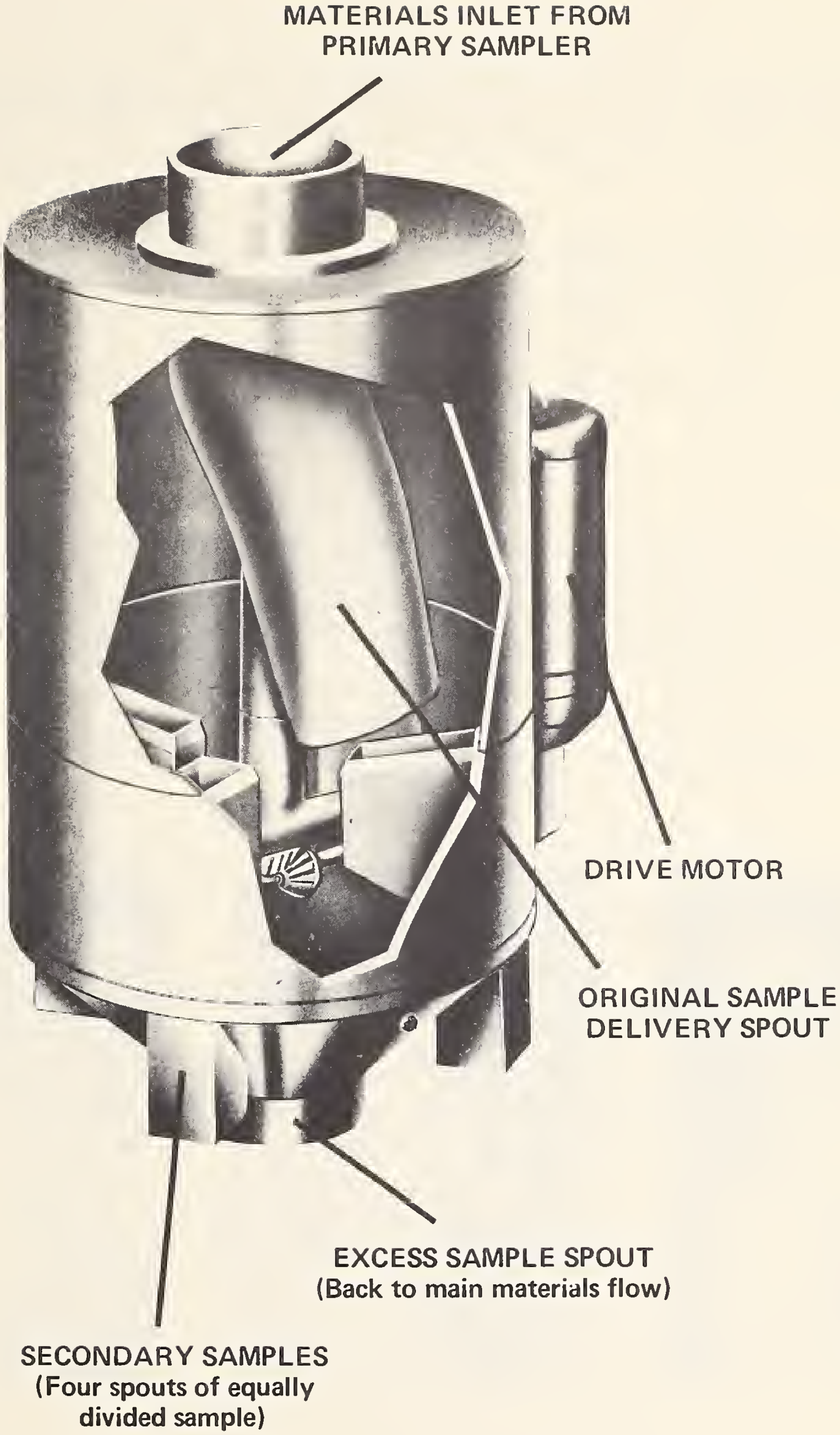

MATERIALS INLET FROM PRIMARY SAMPLER
DRIVE MOTOR
ORIGINAL SAMPLE DELIVERY SPOUT
EXCESS SAMPLE SPOUT (Back to main materials flow)
SECONDARY SAMPLES (Four spouts of equally divided sample)

Figure 4.—Cutaway of a Strand secondary sample divider.

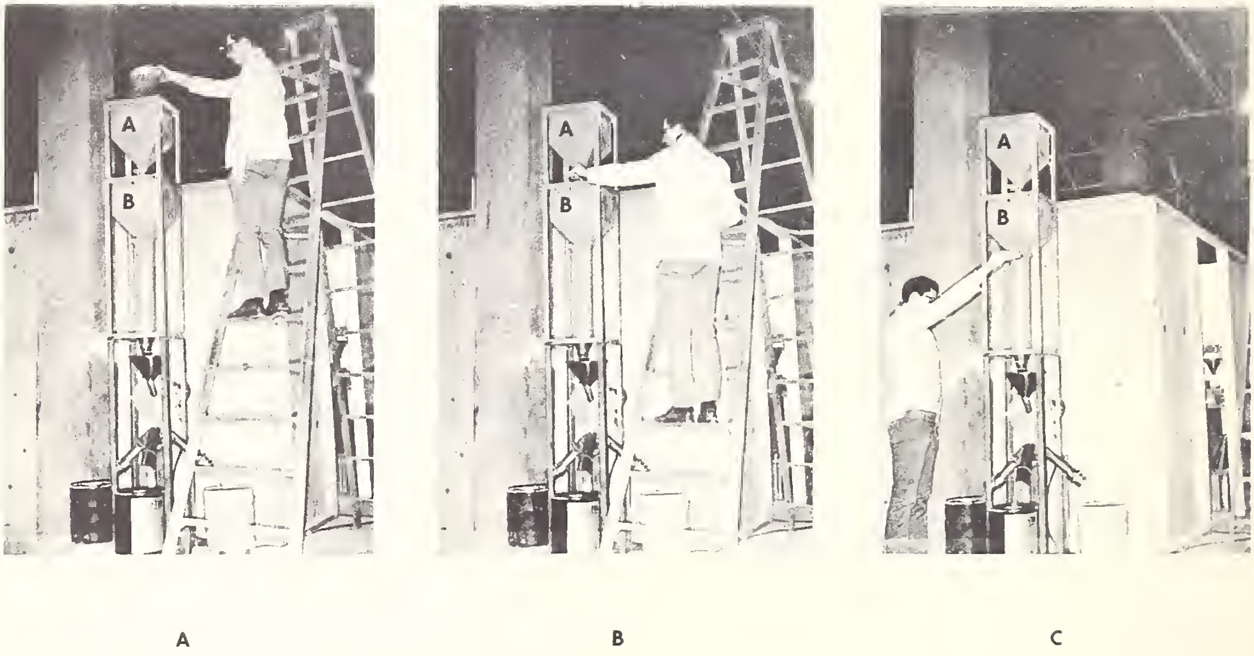
TABLE 4.—Weights of input samples, sizes of feeder orifices, and number and approximate weight of each output sample for the Strand secondary sample divider

Weight of input sample (grams)	Size of feeder orifice	Approximate weight of output sample[1]								
		Number	60 r.p.m.				120 r.p.m.			
			a	b	c	d	a	b	c	d
	Inches		G.	G.	G.	G.	G.	G.	G.	G.
500	1½	4	23	22	29	28	–	–	–	–
1,000	1½	4	53	55	57	49	–	–	–	–
2,500	1½	4	130	129	134	128	–	–	–	–
5,000	1½	4	263	256	270	253	235	257	283	245
5,000	2¼	4	238	233	254	238	239	238	250	253
10,000	2¼	4	499	499	491	492	489	481	512	515

[1] Rest of input sample rejected.

Figure 5 shows the equipment used in preparing the simulated primary samples for testing the four mechanical secondary sample dividers. *A*, shows weighed amounts of each component being layered into hopper A; *B*, the layered components being discharged into hopper B which acts as a mixing cycle of which only one cycle of mixing was used for each simulated primary sample; and *C*, the simulated primary sample being discharged from hopper B into the secondary sampler, a Gamet 7 1/2-inch rotary.

The flow rate of grain through the secondary samplers was controlled by changing the orifice at the end of the 4-inch pipe on the bottom of hopper B. Three sizes of orifice diameters used were 2 1/4 inches, 1 1/2 inches, and 1 3/8 inches.



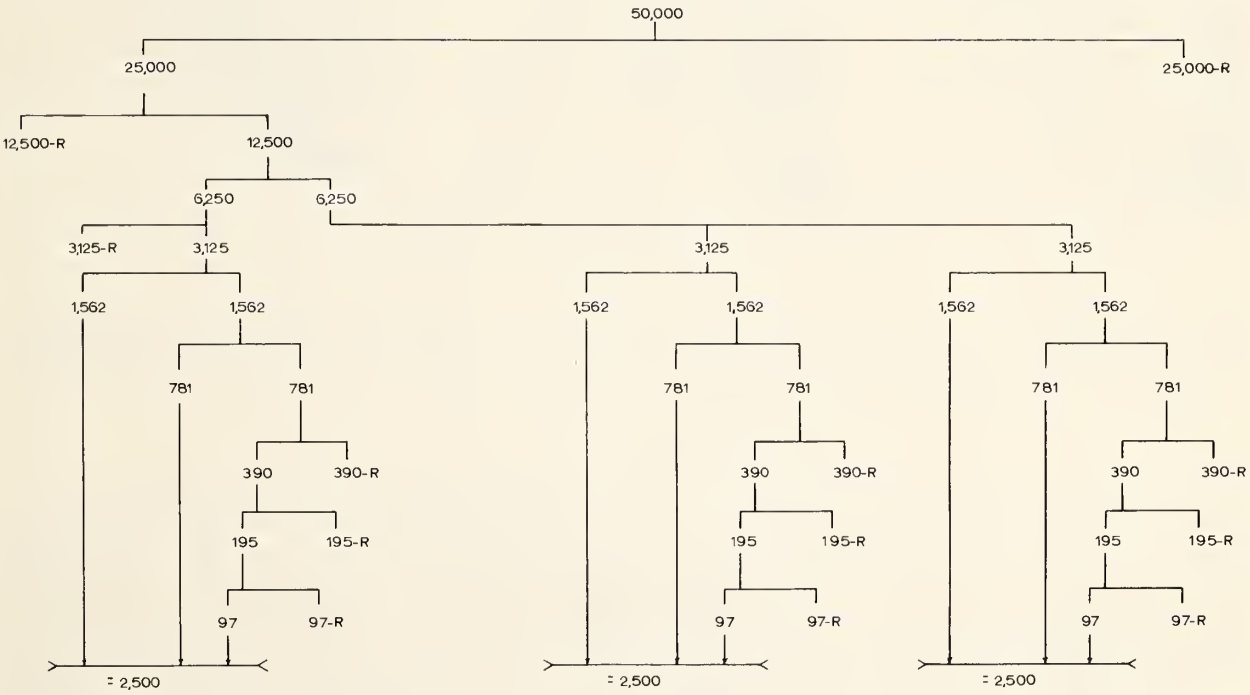
A B C

Figure 5.—Equipment used in preparing the simulated primary samples: A, Components being layered into hopper A; B, layered components being discharged into hopper B; C, simulated primary sample being discharged into a Gamet 7 1/2-inch rotary secondary sample divider.

Gravity-Type Secondary Sample Dividers

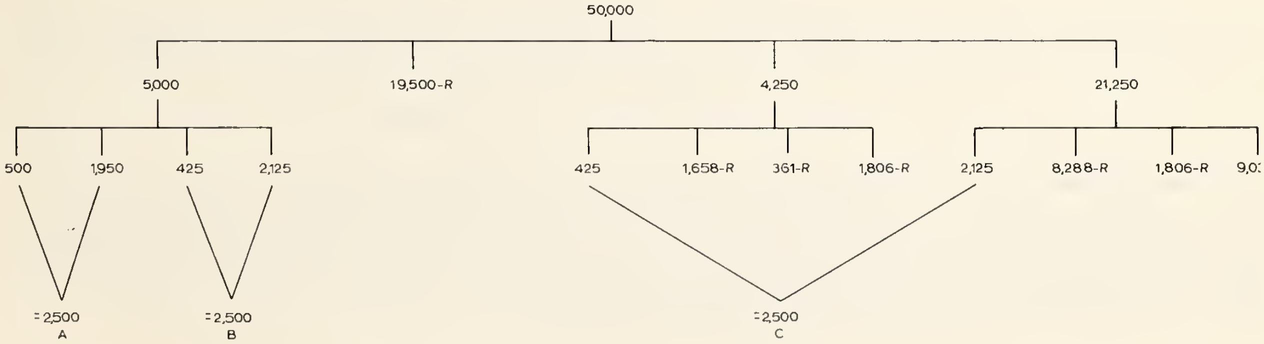
The gravity-type sample dividers evaluated were the Boerner, the Boerner Cargo, and the Boerner 4-Way. The input sample weighed 50,000 grams from which output samples of 2,500 grams each were obtained for each divider. The flow diagram used to obtain the three 2,500-gram-output samples with the Boerner and Cargo is shown in figure 6 and with the 4-Way in figure 7.

Figure 8 shows the equipment used in preparing simulated primary samples for testing the three gravity secondary sample dividers. Figure 8*A* shows weighed amounts of the sample components being layered into hopper A. Figure 8 *B* shows hopper A above hopper B and its contents being discharged into hopper B for the first cycle of



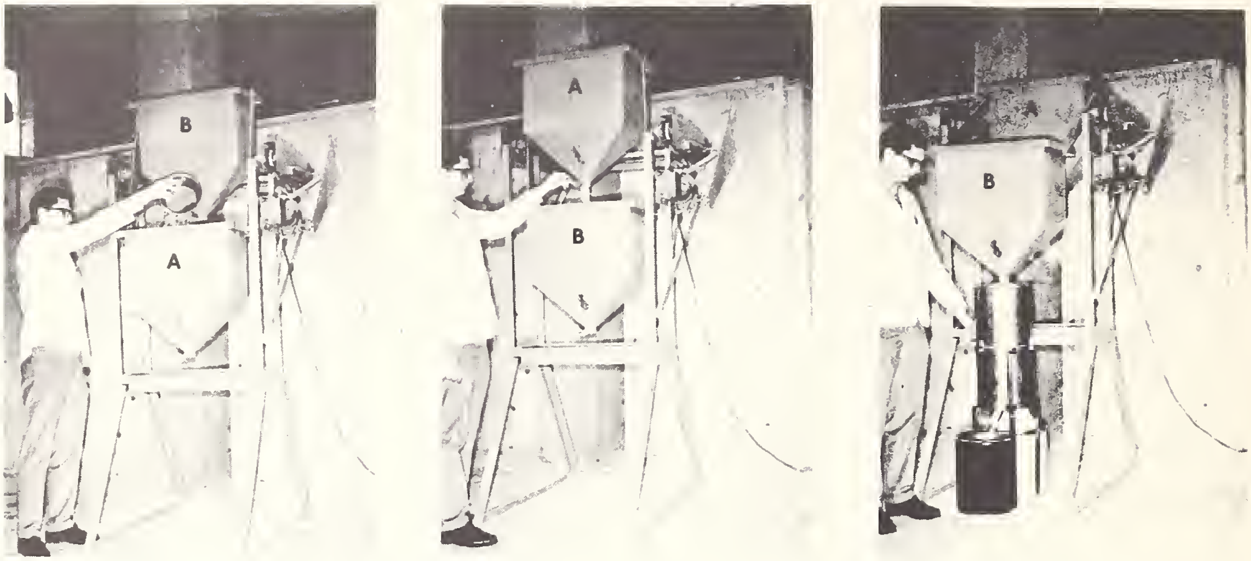
R is rejected portion

Figure 6.—Flow diagram used with the Boerner and Boerner Cargo sample dividers.



R is rejected portion

Figure 7.—Flow diagram used with the Boerner 4-Way sample divider.



A B C

Figure 8.—Equipment used in preparing simulated primary samples for evaluating the gravity-type sample dividers: A, Components being layered into hopper A; B, contents of hopper A being discharged into hopper B for mixing cycle; C, contents of hopper B being discharged into a Boerner secondary sample diver.

mixing. After eight cycles of mixing, the sample was discharged from hopper B into the secondary sample divider (Fig. 8 *C*). The three 2,500-gram subsamples were obtained by manually performing the procedures shown in figure 8.

TESTING PROCEDURE

Data from 10 replications for each of the grain lots and for each primary sample size were used in evaluating all sample dividers except the Strand. In evaluating this divider, 10 replications of the wheat lot only were used. Component analyses of all the samples, except those from the Strand, were performed by the Minneapolis Laboratory of the Grain Division, Consumer and Marketing Service, U.S. Department of Agriculture. Cargill, Inc., did the component analyses of the samples from the Strand Sample Divider.

Averages over the 10 replications with standard deviations, 95 percent confidence intervals, and minimum and maximum values were determined for each of the component percentages for each different testing situation.

Two criteria, established for evaluating sampler performance, were as follows:

Criterion No. 1.—The known percentage of a component in the primary sample (from which a secondary sample is drawn) must be included in the calculated 95 percent confidence interval (C.I.) of the component percentage in secondary samples. The known percentage, however, may be *outside* the calculated confidence interval if the confidence interval is so small and also so close to the known percentage that the confidence interval includes no percentages greater than 0.50 percent from the known percentage.

Criterion No. 2.—When component percentages in secondary samples are determined in repeated tests made under identical conditions, no more than 1 out of 10 component percentages (on the average) may be further than 0.5 percent from the average component percentage.

Criterion No. 1 uses 95-percent confidence intervals of average component percentages. The chances are approximately 19 to 1 that the confidence intervals shown in tables 5 through 16 contain the true component percentages in the secondary samples. When these confidence intervals did not include the component percentage known to have been present in the primary sample (from which the secondary sample was drawn), the secondary sampler was considered as producing biased samples. The exception contained in criterion No. 1 allows for consistent, but very small, biases in estimates of component percentages. These biases are permitted only when the component percentage estimates can be obtained with a high degree of repeatability. For example, a sampler would probably be acceptable if it consistently produced samples with 0.10 percent more screenings than were known to be present in the primary sample, provided that the range of screening percentages in secondary samples were small.

In applying criterion No. 2, it was determined that if a population of component percentage values had a variance[3] of 0.092 percent, no more than one observation in 10 (on the average) would deviate more than 0.50 percent from the true component percentage. Further calculations, allowing for the usual variability in estimates of variance, showed that when 95 percent confidence intervals were 0.29 percent or less from the mean, criterion No. 2 would be satisfied. Calculations are outlined in the appendix.

Criterion No. 1 demands that a sampler produce secondary samples having an *average* component percentage within 0.5 percent of the amount known to be present in the primary sample. Poor sampling devices might be able to meet this criterion. For example, replicate secondary samples could range from 1 to 10 percent component and yet produce an average component percent equal to a known 5 percent. Criterion No. 2 was established to take care of this situation. Criterion No. 2 demands that results from a sampler be consistent over replications. If both criteria are to be met by a sampler, the component content of nearly all secondary samples must be close to the known amount of the component.

RESULTS AND DISCUSSION

Sample dividers cannot be compared directly with one another because of the various test procedures used. Confidence intervals and the established criteria, however, make it possible to evaluate the performance of each sample divider.

The wheat lot was the fastest flowing followed by the soybeans and then the corn. The wheat lot was generally the most difficult to accurately divide followed by the corn and soybean lots as judged by the confidence intervals, minimums, and maximums. The component corn in the wheat lot was the most difficult of all components to accurately divide for all sample dividers.

As the size of the primary sample was increased with a resulting increase in the weight of the secondary sample, the more accurate the sample division. The most difficult sample to divide for all samplers was the 500-gram primary sample.

The data and the statistical analyses of the data for all sample dividers evaluated are reported in tables 5 to 16. A discussion of the performance of each sample divider follows.

GAMET 7 1/2-INCH LABORATORY TYPE

The data for the Gamet 7 1/2-inch are included in tables 5 to 7. The average weight of the secondary samples was consistent for each of the three grains. The percent corn in the wheat lot varied considerably more than the screenings. The corn in the wheat was the most difficult component to sample. The greatest variation in percentage components in the three output samples occured in the smallest output sample (sample *a*). Criterion No. 1 was met for all samples. As the size of the primary sample was increased, the more often the sample divider met criterion No.

---

[3] Variance is a statistic used for expressing the dispersion of individual observations around the mean. The square root of variance is the standard deviation.

TABLE 5.—Data for the Gamet 7½-inch laboratory-type sample divider for the components corn and screenings in the wheat lot

Weight of primary sample & component	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
	Inches		Grams	Seconds	Percent	Percent	Percent		
500 g.:									
Corn	1½	a	51	2.00	4.80 ± 1.39	1.36	7.28	Yes	No
		b	199	2.00	4.91 ± .44	3.79	6.24	Yes	No
		c	249	2.00	5.34 ± .39	4.55	6.22	Yes	No
Screenings		a	51	2.00	5.09 ± .30	4.37	5.73	Yes	No
		b	199	2.00	5.00 ± .06	4.90	5.16	Yes	Yes
		c	249	2.00	5.03 ± .07	4.89	5.15	Yes	Yes
1,000 g.:									
Corn	1½	a	98	3.75	5.53 ± .86	3.98	7.67	Yes	No
		b	398	3.75	4.88 ± .36	3.73	5.52	Yes	No
		c	501	3.75	5.18 ± .31	4.55	6.07	Yes	No
Screenings		a	98	3.75	4.89 ± .35	4.37	5.70	Yes	No
		b	398	3.75	5.06 ± .07	4.87	5.19	Yes	Yes
		c	501	3.75	5.04 ± .08	4.90	5.25	Yes	Yes
2,500 g.:									
Corn	1½	a	248	8.43	4.91 ± .43	4.12	6.28	Yes	No
		b	998	8.43	4.98 ± .22	4.57	5.44	Yes	Yes
		c	1,249	8.43	5.18 ± .17	4.74	5.47	Yes	Yes
Screenings		a	248	8.43	4.97 ± .17	4.67	5.29	Yes	Yes
		b	998	8.43	5.08 ± .03	5.00	5.14	Yes	Yes
		c	1,249	8.43	5.04 ± .05	4.94	5.20	Yes	Yes
5,000 g.:									
Corn	1½	a	499	16.90	4.99 ± .40	4.49	6.26	Yes	No
		b	1,993	16.90	5.05 ± .16	4.81	5.50	Yes	Yes
		c	2,494	16.90	5.03 ± .11	4.77	5.29	Yes	Yes
Screenings		a	499	16.90	5.06 ± .07	4.87	5.21	Yes	Yes
		b	1,993	16.90	5.06 ± .03	5.01	5.12	Yes	Yes
		c	2,494	16.90	5.07 ± .03	5.01	5.13	Yes	Yes

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent for both corn and screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

2. This criterion was satisfied more often in the larger secondary samples (output samples *b* and c) than in the smallest output sample (sample *a*).

Criterion No. 2 was not met for the component corn in the wheat lot in any output sample when the primary sample was 500 or 1,000 grams. Criterion No. 2 was not satisifed for output sample *a* for the component corn in wheat regardless of the primary sample weight. It was satisfied for the screenings in wheat in all *b* and *c* samples at all primary sample weights. At only the largest primary sample weight (5,000 grams) was criterion No. 2 satisfied for output sample *a* for the screenings in wheat.

Criterion No. 2 was not satisfied for wheat in the corn lot for output sample *a* for primary sample weights of 500 and 1,000 grams (table 6). In all samples, criteria No. 1 and No. 2 were satisfied for screenings in the soybeans (table 7).

TABLE 6.—Data for the Gamet 7½-inch laboratory-type sample divider for the component wheat in the corn lot

Weight of primary sample	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
Grams	Inches		Grams	Seconds	Percent	Percent	Percent		
500	1½	a	50	2.35	5.22 ± .44	4.33	6.45	Yes	No
		b	200	2.35	4.94 ± .17	4.56	5.24	Yes	Yes
		c	250	2.35	4.91 ± .15	4.63	5.16	Yes	Yes
1,000	1½	a	102	4.50	5.06 ± .38	3.93	5.79	Yes	No
		b	397	4.50	4.99 ± .10	4.74	5.27	Yes	Yes
		c	499	4.50	4.92 ± .08	4.75	5.08	Yes	Yes
2,500	1½	a	252	10.75	4.91 ± .16	4.68	5.28	Yes	Yes
		b	994	10.75	4.97 ± .05	4.86	5.10	Yes	Yes
		c	1,250	10.75	4.93 ± .04	4.84	5.02	Yes	Yes
5,000	1½	a	497	23.03	4.94 ± .17	4.62	5.30	Yes	Yes
		b	1,993	23.03	4.89 ± .06	4.75	5.01	Yes	Yes
		c	2,499	23.03	4.97 ± .04	4.87	5.07	Yes	Yes

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5 percent wheat.

[3] Mean and confidence interval (C.I.) of the mean, respectively.

TABLE 7.—Data for the Gamet 7½-inch laboratory-type sample divider for the component screenings in the soybean lot

Weight of primary sample	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
Grams	Inches		Grams	Seconds	Percent	Percent	Percent		
500	1½	a	50	2.30	5.14 ± .27	4.56	5.73	Yes	Yes
		b	200	2.30	5.00 ± .08	4.83	5.14	Yes	Yes
		c	249	2.30	5.09 ± .08	4.95	5.32	Yes	Yes
1,000	1½	a	100	4.28	5.01 ± .19	4.68	5.40	Yes	Yes
		b	399	4.28	5.02 ± .08	4.87	5.22	Yes	Yes
		c	499	4.28	5.10 ± .06	4.96	5.23	Yes	Yes
2,500	1½	a	249	10.10	5.02 ± .09	4.88	5.24	Yes	Yes
		b	967	10.10	5.01 ± .07	4.84	5.16	Yes	Yes
		c	1,249	10.10	5.05 ± .05	4.90	5.14	Yes	Yes
5,000	1½	a	501	19.90	5.00 ± .07	4.88	5.17	Yes	Yes
		b	1,994	19.90	5.07 ± .02	5.03	5.12	Yes	Yes
		c	2,492	19.90	5.03 ± .03	4.97	5.10	Yes	Yes

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

GAMET 12-INCH

The data for the Gamet 12-inch are reported in tables 8 to 10. The three output samples were nearly the same weight. There was a wide variation between the minimum and maximum for corn in wheat (table 8). This variation was less for screenings in wheat, which corresponds to results for the Gamet 7 1/2-inch. Criterion No. 1 was satisfied

TABLE 8.—Data for the Gamet 12-inch sample divider for the components corn and screenings in the wheat lot

Weight of primary sample & component	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]: Mean and C.I.[1,3]	Percent component in secondary samples[2]: Minimum	Percent component in secondary samples[2]: Maximum	Results met criterion—: No. 1	Results met criterion—: No. 2
	Inches		Grams	Seconds	Percent	Percent	Percent		
500 g.:									
Corn	1½	a	28	2.00	5.62 ± 1.97	2.41	9.81	Yes	No
		b	27	2.00	4.02 ± 1.19	2.17	7.54	Yes	No
		c	28	2.00	4.68 ± 1.52	1.44	8.03	Yes	No
Screenings		a	28	2.00	5.26 ± .16	4.92	5.61	Yes	Yes
		b	27	2.00	5.31 ± .24	4.76	5.73	No	Yes
		c	28	2.00	5.21 ± .16	4.85	5.63	Yes	Yes
1,000 g.:									
Corn	1½	a	55	3.50	5.11 ± .68	3.96	6.45	Yes	No
		b	54	3.50	4.99 ± .94	3.17	7.21	Yes	No
		c	55	3.50	5.01 ± 1.23	3.27	8.21	Yes	No
Screenings		a	55	3.50	5.15 ± .13	4.88	5.47	Yes	Yes
		b	54	3.50	5.22 ± .22	4.52	5.59	Yes	Yes
		c	55	3.50	5.16 ± .12	4.80	5.42	Yes	Yes
2,500 g.:									
Corn	1½	a	52	7.60	4.58 ± 1.46	1.86	7.50	Yes	No
		b	52	7.60	5.01 ± .97	2.13	6.77	Yes	No
		c	52	7.60	4.74 ± .64	3.44	6.08	Yes	No
Screenings		a	52	7.60	5.09 ± .18	4.69	5.47	Yes	Yes
		b	52	7.60	5.04 ± .10	4.78	5.24	Yes	Yes
		c	52	7.60	4.94 ± .17	4.64	5.37	Yes	Yes
5,000 g.:									
Corn	1½	a	104	19.00	5.26 ± .62	3.48	6.47	Yes	No
		b	104	19.00	5.24 ± 1.20	3.05	8.65	Yes	No
		c	105	19.00	5.03 ± .90	3.79	7.94	Yes	No
Screenings		a	104	19.00	5.16 ± .08	4.93	5.30	Yes	Yes
		b	104	19.00	5.07 ± .06	4.94	5.20	Yes	Yes
		c	105	19.00	5.07 ± .06	4.94	5.19	Yes	Yes
5,000 g.:									
Corn	2¼	a	57	3.50	4.33 ± .93	2.60	6.79	Yes	No
		b	58	3.50	5.35 ± .65	4.20	6.63	Yes	No
		c	58	3.50	5.10 ± .67	3.56	6.48	Yes	No
Screenings		a	57	3.50	5.21 ± .14	4.77	5.53	Yes	Yes
		b	58	3.50	5.05 ± .14	4.77	5.37	Yes	Yes
		c	58	3.50	5.01 ± .11	4.81	5.31	Yes	Yes
10,000 g.:									
Corn	2¼	a	117	8.90	5.87 ± .82	4.13	7.12	No	No
		b	115	8.90	4.83 ± .71	2.95	6.44	Yes	No
		c	114	8.90	4.86 ± .57	3.92	6.08	Yes	No
Screenings		a	117	8.90	4.99 ± .09	4.83	5.18	Yes	Yes
		b	115	8.90	5.06 ± .06	4.94	5.22	Yes	Yes
		c	114	8.90	5.13 ± .09	4.86	5.33	Yes	Yes

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent for both corn and screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

in all but two tests of corn and screenings in wheat (table 8). However, criterion No. 2 was not met in any of the tests for corn in the wheat lot. Criterion No. 2 was satisfied in all tests of the screenings in the wheat lot.

There was considerable variation for wheat in the corn lot with all primary sample weights (table 9). In all tests criterion No. 1 was satisfied, but criterion No. 2 was satisifed in only two.

Variation of the screenings in the soybean lot was small (table 10). Both criteria were satisfied in all samples.

DENVER 15-INCH VEZIN

Data for the Denver 15-inch Vezin are reported in tables 11 to 13. There was only one secondary sample obtained from each primary sample with this divider. Variations from the mean were extensive, and there was a wide spread between the minimum and maximum percentages in replicate tests.

Criterion No. 1 and No. 2 were not satisfied for either corn or screenings in the wheat lot with the 500-gram primary sample (table 11). Criterion No. 1 was satisfied for all other samples, but criterion No. 2 was satisfied in only one test of the wheat lot (table 11).

TABLE 9.—Data for the Gamet 12-inch sample divider for the component wheat in the corn lot

Weight of primary sample	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
Grams	Inches		Grams	Seconds	Percent	Percent	Percent		
500	1½	a	27	2.50	5.49 ± .67	3.64	6.79	Yes	No
		b	28	2.50	5.03 ± .78	3.39	6.89	Yes	No
		c	28	2.50	4.90 ± .44	4.12	5.73	Yes	No
1,000	1½	a	54	4.35	5.33 ± .69	4.14	7.17	Yes	No
		b	56	4.35	5.04 ± .29	4.38	5.66	Yes	Yes
		c	55	4.35	5.30 ± .34	4.35	5.95	Yes	No
2,500	1½	a	51	10.00	5.21 ± .59	4.18	6.52	Yes	No
		b	52	10.00	5.35 ± .43	4.54	6.33	Yes	No
		c	52	10.00	5.26 ± .63	4.26	7.29	Yes	No
5,000	1½	a	106	19.50	5.07 ± .38	4.34	5.91	Yes	No
		b	105	19.50	5.09 ± .30	4.40	5.68	Yes	No
		c	103	19.50	5.16 ± .35	4.29	6.08	Yes	No
5,000	2¼	a	58	5.00	4.86 ± .44	3.94	5.82	Yes	No
		b	57	5.00	4.94 ± .45	3.53	5.81	Yes	No
		c	59	5.00	4.94 ± .48	3.70	6.15	Yes	No
10,000	2¼	a	118	10.40	4.77 ± .29	4.26	5.34	Yes	Yes
		b	115	10.40	5.01 ± .31	4.57	5.83	Yes	No
		c	114	10.40	5.08 ± .31	4.56	5.82	Yes	No

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent wheat.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

TABLE 10.—Data for the Gamet 12-inch sample divider for the component screenings in the soybean lot

Weight of primary sample	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2] Mean and C.I. [1, 3]	Mini-mum	Maxi-mum	Results met criterion— No. 1	No. 2
Grams	Inches		Grams	Seconds	Percent	Percent	Percent		
500	1½	a	29	2.50	4.95 ± .25	4.32	5.52	Yes	Yes
		b	27	2.50	5.23 ± .21	4.59	5.59	Yes	Yes
		c	28	2.50	5.13 ± .23	4.62	5.62	Yes	Yes
1,000	1½	a	55	4.00	5.15 ± .22	4.78	5.88	Yes	Yes
		b	55	4.00	5.07 ± .25	4.63	5.90	Yes	Yes
		c	56	4.00	5.00 ± .19	4.56	5.46	Yes	Yes
2,500	1½	a	52	8.65	5.03 ± .23	4.43	5.49	Yes	Yes
		b	51	8.65	5.12 ± .29	4.41	5.60	Yes	Yes
		c	52	8.65	4.95 ± .17	4.66	5.33	Yes	Yes
5,000	1½	a	106	16.20	5.02 ± .09	4.79	5.20	Yes	Yes
		b	102	16.20	5.19 ± .11	4.95	5.50	Yes	Yes
		c	102	16.20	5.11 ± .15	4.75	5.38	Yes	Yes
5,000	2¼	a	58	5.20	5.06 ± .20	4.71	5.59	Yes	Yes
		b	57	5.20	5.12 ± .14	4.82	5.36	Yes	Yes
		c	58	5.20	4.97 ± .13	4.76	5.40	Yes	Yes
10,000	2¼	a	115	9.85	5.16 ± .14	4.75	5.43	Yes	Yes
		b	118	9.85	4.95 ± .13	4.76	5.33	Yes	Yes
		c	112	9.85	5.18 ± .18	4.83	5.56	Yes	Yes

[1] Average of 10 replications.
[2] Known percent component in the primary sample was 5.0 percent screenings.
[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

The amount of wheat in the corn lot (table 12) and the amount of screenings in the soybean lot (table 13) varied extensively between replicates, as indicated by the confidence intervals, minimums, and maximums. Criterion No. 1 was satisfied in all samples for the corn lot, but criterion No. 2 was not satisfied in any sample. For the soybean lot criterion No. 1 was satisfied in four of six samples. Criterion No. 2 was satisfied only once.

STRAND

The data for the Strand are reported in tables 14 and 15. Only the wheat lot was used in evaluating this sample divider. The weights of the four output samples from each size of primary sample and orifice were quite close. As with the other samplers, generally corn had more variations than screenings in the wheat. At 60 r.p.m., criterion No. 1 was met in all but two tests; however, criterion No. 2 was seldom satisfied (table 14). At 120 r.p.m., criterion No. 1 was not satisfied in four samples; criterion No. 2 was satisfied in seven (table 15).

GRAVITY-TYPE SAMPLE DIVIDERS

The data for the Boerner, Cargo, and 4-Way sample dividers are reported in table 16. The variation in percent components in the secondary samples for the Boerner and Cargo dividers was small as shown by the confidence intervals, minimums, and maximums. Criteria No. 1 and No. 2 were satisfied in all tests with the Boerner and Cargo. More variation in the percent components in the secondary samples was obtained with the 4-Way than with either the Boerner or Cargo (table 16). Criteria No. 1 and No. 2 were satisfied only with the soybean lot.

TABLE 11.—Data for the Denver 15-inch Vezin sample divider for the components corn and screenings in the wheat lot

Weight of primary sample & component	Size of feeder orifice	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion--	
				Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
	Inches	Grams	Seconds	Percent	Percent	Percent		
500 g.:								
Corn	1 3/8	20	1.75	1.97 ± .76	0.51	3.55	No	No
Screenings		20	1.75	1.51 ± .38	.99	2.49	No	No
1,000 g.:								
Corn	1 3/8	29	3.48	4.60 ±2.31	0	11.21	Yes	No
Screenings		29	3.48	4.10 ±2.02	1.05	9.59	Yes	No
2,500 g.:								
Corn	1 3/8	70	7.73	5.54 ± .85	3.42	7.19	Yes	No
Screenings		70	7.73	5.52 ±1.07	2.83	7.83	Yes	No
5,000 g.:								
Corn	1 3/8	139	14.98	5.07 ± .73	3.68	6.78	Yes	No
Screenings		139	14.98	5.10 ± .26	4.38	5.63	Yes	Yes
5,000 g.:								
Corn	2 1/4	136	3.95	3.73 ±2.00	1.18	9.59	Yes	No
Screenings		136	3.95	3.26 ±2.13	.24	10.34	Yes	No
10,000 g.:								
Corn	2 1/4	245	8.25	5.44 ± .90	3.35	6.92	Yes	No
Screenings		245	8.25	5.32 ±1.49	1.40	7.40	Yes	No

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent for both corn and screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

TABLE 12.—Data for the Denver 15-inch Vezin sample divider for the component wheat in the corn lot

Weight of primary sample	Size of feeder orifice	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion--	
				Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
Grams	Inches	Grams	Seconds	Percent	Percent	Percent		
500	1 3/8	11	2.73	4.53 ±0.87	2.73	6.19	Yes	No
1,000	1 3/8	24	4.83	5.15 ± .83	3.57	7.00	Yes	No
2,500	1 3/8	65	11.50	5.12 ± .47	3.94	5.94	Yes	No
5,000	1 3/8	135	22.20	4.88 ± .35	3.89	5.58	Yes	No
5,000	2 1/4	112	2.15	4.19 ±1.29	1.27	6.28	Yes	No
10,000	2 1/4	180	4.03	3.87 ±2.32	.75	7.87	Yes	No

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent wheat.

[3] Mean and 95 percent confidence (C.I.) interval of the mean, respectively.

TABLE 13.—Data for the Denver 15-inch Vezin sample divider for the component screenings in the soybean lot.

Weight of primary sample	Size of feeder orifice	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
				Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
Grams	Inches	Grams	Seconds	Percent	Percent	Percent		
500	1 3/8	15	2.05	3.87 ±0.41	3.27	5.11	No	No
1,000	1 3/8	23	4.03	3.84 ±1.87	1.42	8.65	Yes	No
2,500	1 3/8	66	9.55	5.52 ±1.17	2.83	7.25	Yes	No
5,000	1 3/8	132	18.50	5.38 ± .29	4.71	6.02	No	Yes
5,000	2 1/4	115	4.80	3.87 ±1.68	1.20	7.83	Yes	No
10,000	2 1/4	241	9.58	5.47 ± .60	4.76	7.09	Yes	No

[1] Average of 10 replications.
[2] Known percent component in the primary sample was 5.0 percent screenings.
[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

A summary of the sample dividers meeting or not meeting the established criteria is reported in tables 17 to 19. No mechanical sampler satisfied all the criteria under any of the operating conditions subjected for the wheat lot. Of the gravity-type dividers, the Boerner and the Cargo met the criteria for the wheat lot; the 4-Way did not.

In sampling the corn lot, only the Gamet 7 1/2-inch with the 2,500 and 5,000 gram primary samples satisfied the criteria. The other mechanical samplers did not satisfy the criteria under any condition. As with the wheat lot, the Boerner and Cargo gravity-type dividers met the criteria, but the 4-Way did not.

In dividing the soybean lot, the Gamet 7 1/2- and 12-inch dividers met the criteria for all primary sample weights, but the Denver sampler did not meet any. All three gravity-type dividers satisfied the criteria for this lot.

The test conditions under which the sample dividers were evaluated in this research were severe. The grains were not well mixed, and the component percentages were high. Therefore, it is to be expected that the sample dividers would not meet the criteria established in many tests. This would be especially true when drawing a small sample from larger primary samples. However, a system of a mechanical diverter-type primary sampler and a mechanical-type secondary sample divider is probably the most useful method available today for sampling grains being loaded in or out. This method is certainly more accurate and practical than the probe technique of sampling hopper cars. This research, however, does not preclude the use of mechanical secondary sample dividers. Rather, research must be aimed at improving procedures for using dividers that are now available and at improving the design of these dividers.

TABLE 14.—Data for the Strand sample divider running at 60 r.p.m. for the components corn and screenings in the wheat lot

Weight of primary sample & component	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion—	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
	Inches		Grams	Seconds	Percent	Percent	Percent		
500 g.:									
Corn	1½	a	23	1.79	4.66 ± 1.43	1.33	7.21	Yes	No
		b	22	1.79	3.46 ± 2.42	0	11.27	Yes	No
		c	29	1.79	4.88 ± 2.08	0	10.59	Yes	No
		d	28	1.79	3.23 ± 1.36	.88	6.73	No	No
Screenings		a	23	1.79	5.46 ± 2.19	2.67	12.88	Yes	No
		b	22	1.79	3.80 ± 1.27	1.35	7.04	Yes	No
		c	29	1.79	5.39 ± 1.64	2.62	9.30	Yes	No
		d	28	1.79	4.33 ± .79	2.63	6.48	Yes	No
1,000 g.:									
Corn	1½	a	53	3.29	5.14 ± 1.11	2.47	7.63	Yes	No
		b	55	3.29	5.48 ± 2.13	1.97	11.08	Yes	No
		c	57	3.29	4.73 ± 1.22	2.65	8.25	Yes	No
		d	49	3.29	4.64 ± 1.09	2.83	7.78	Yes	No
Screenings		a	53	3.29	5.00 ± .77	3.40	7.19	Yes	No
		b	55	3.29	5.19 ± .43	3.05	7.67	Yes	No
		c	57	3.29	5.39 ± 1.00	2.91	8.11	Yes	No
		d	49	3.29	4.93 ± .75	3.38	6.20	Yes	No
2,500 g.:									
Corn	1½	a	130	7.90	4.53 ± .59	3.61	6.36	Yes	No
		b	129	7.90	4.82 ± .77	3.36	7.03	Yes	No
		c	134	7.90	5.21 ± .70	3.71	6.93	Yes	No
		d	128	7.90	5.74 ± .86	4.55	7.86	Yes	No
Screenings		a	130	7.90	4.90 ± .38	3.91	5.47	Yes	No
		b	129	7.90	4.90 ± .57	3.89	5.68	Yes	No
		c	134	7.90	4.83 ± 1.00	.99	5.65	Yes	No
		d	128	7.90	5.08 ± .36	4.00	5.62	Yes	No
5,000 g.:									
Corn	1½	a	263	3.47	4.95 ± .39	4.23	6.12	Yes	No
		b	256	3.47	5.32 ± .52	4.45	6.76	Yes	No
		c	270	3.47	4.69 ± .29	3.96	5.02	No	Yes
		d	253	3.47	4.62 ± .50	3.62	5.62	Yes	No
Screenings		a	263	3.47	4.90 ± .25	4.42	5.59	Yes	Yes
		b	256	3.47	5.10 ± .25	4.78	5.82	Yes	Yes
		c	270	3.47	4.90 ± .23	4.39	5.40	Yes	Yes
		d	253	3.47	4.88 ± .25	4.58	5.55	Yes	Yes
5,000 g.:									
Corn	2¼	a	238	15.72	4.83 ±1.36	1.96	7.25	Yes	No
		b	233	15.72	5.42 ±1.56	1.01	7.57	Yes	No
		c	254	15.72	4.44 ±1.58	1.65	8.36	Yes	No
		d	238	15.72	5.46 ± .86	3.41	6.92	Yes	No
Screenings		a	238	15.72	5.19 ±1.20	2.13	7.01	Yes	No
		b	233	15.72	5.30 ±1.49	1.51	8.22	Yes	No
		c	254	15.72	4.34 ±1.45	1.67	7.31	Yes	No
		d	238	15.72	5.84 ±1.58	2.43	8.45	Yes	No

TABLE 14.–(Continued)

Weight of primary sample & component	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion–	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
	Inches		Grams	Seconds	Percent	Percent	Percent		
10,000 g.:									
Corn	2¼	a	499	7.24	4.94 ± .50	3.96	6.25	Yes	No
		b	499	7.24	5.04 ± .32	4.10	5.71	Yes	No
		c	491	7.24	5.06 ± .38	4.20	5.96	Yes	No
		d	492	7.24	4.82 ± .36	4.25	5.63	Yes	No
Screenings		a	499	7.24	4.97 ± .63	3.70	6.79	Yes	No
		b	499	7.24	5.24 ± .32	4.31	5.90	Yes	No
		c	491	7.24	4.76 ± .41	4.00	5.67	Yes	No
		d	492	7.24	4.75 ± .32	4.03	5.31	Yes	No

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent for both corn and screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

TABLE 15.–Data for the Strand sample divider running at 120 r.p.m. for the components corn and screenings in the wheat lot

Weight of primary sample & component	Size of feeder orifice	Output sample	Average weight of secondary samples[1]	Average flow time[1]	Percent component in secondary samples[2]			Results met criterion–	
					Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
	Inches		Grams	Seconds	Percent	Percent	Percent		
5,000 g.:									
Corn	1½	a	235	16.10	5.01 ±0.61	4.10	6.70	Yes	No
		b	257	16.10	4.83 ± .41	4.16	5.49	Yes	No
		c	283	16.10	4.26 ± .52	3.39	5.82	No	No
		d	245	16.10	5.47 ± .68	4.14	6.48	Yes	No
Screenings		a	235	16.10	5.02 ± .16	4.66	5.26	Yes	Yes
		b	257	16.10	4.85 ± .27	4.27	5.70	Yes	No
		c	283	16.10	4.70 ± .18	4.16	5.06	Yes	Yes
		d	245	16.10	5.42 ± .23	4.65	5.79	Yes	Yes
5,000 g.:									
Corn	2¼	a	239	4.61	5.19 ± .93	3.44	7.42	Yes	No
		b	238	4.61	4.31 ± .48	3.32	5.16	No	No
		c	250	4.61	4.72 ± .81	3.66	7.13	Yes	No
		d	253	4.61	5.24 ± .63	3.08	6.12	Yes	No
Screenings		a	239	4.61	5.30 ± .75	3.59	6.48	Yes	No
		b	238	4.61	4.85 ± .52	4.06	6.26	Yes	No
		c	250	4.61	4.58 ± .52	3.41	5.52	Yes	No
		d	253	4.61	4.79 ± .38	3.88	5.48	Yes	No
10,000 g.:									
Corn	2¼	a	489	10.04	5.00 ± .39	4.30	6.03	Yes	No
		b	481	10.04	4.49 ± .36	3.63	5.30	No	No
		c	512	10.04	4.54 ± .25	3.95	5.22	No	Yes
		d	515	10.04	5.09 ± .18	4.70	5.44	Yes	Yes
Screenings		a	489	10.04	5.10 ± .25	4.68	5.72	Yes	Yes
		b	481	10.04	4.81 ± .52	3.81	6.06	Yes	No
		c	512	10.04	4.84 ± .38	4.10	5.95	Yes	No
		d	515	10.04	5.25 ± .36	4.58	5.89	Yes	No

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent for both corn and screenings.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

TABLE 16.–Data for the gravity-type sample dividers

Sampler and principal component in primary sample	Output sample	Average weight of secondary samples[1]	Component in samples	Percent component in secondary samples[2]			Results met criterion--	
				Mean and C.I.[1,3]	Minimum	Maximum	No. 1	No. 2
		Grams		Percent	Percent	Percent		
BOERNER								
Wheat	a	2,484	Corn	4.83 ±0.09	4.57	5.02	Yes	Yes
Wheat	b	2,453	Corn	5.00 ± .16	4.67	5.38	Yes	Yes
Wheat	c	2,484	Corn	4.83 ± .17	4.49	5.24	Yes	Yes
Wheat	a	2,484	Screenings	4.97 ± .09	4.62	5.07	Yes	Yes
Wheat	b	2,453	Screenings	5.02 ± .03	4.96	5.09	Yes	Yes
Wheat	c	2,484	Screenings	5.02 ± .02	4.97	5.09	Yes	Yes
Corn	a	2,467	Wheat	4.99 ± .05	4.88	5.09	Yes	Yes
Corn	b	2,536	Wheat	5.00 ± .05	4.93	5.13	Yes	Yes
Corn	c	2,497	Wheat	4.93 ± .07	4.78	5.14	Yes	Yes
Soybeans	a	2,568	Screenings	5.02 ± .03	4.97	5.08	Yes	Yes
Soybeans	b	2,557	Screenings	4.99 ± .03	4.93	5.10	Yes	Yes
Soybeans	c	2,561	Screenings	4.99 ± .04	4.89	5.07	Yes	Yes
CARGO								
Wheat	a	2,494	Corn	4.99 ± .12	4.69	5.23	Yes	Yes
Wheat	b	2,487	Corn	4.87 ± .18	4.46	5.22	Yes	Yes
Wheat	c	2,485	Corn	4.92 ± .09	4.64	5.10	Yes	Yes
Wheat	a	2,494	Screenings	4.85 ± .07	4.72	5.01	Yes	Yes
Wheat	b	2,487	Screenings	4.87 ± .06	4.73	4.98	Yes	Yes
Wheat	c	2,485	Screenings	4.86 ± .03	4.80	4.93	Yes	Yes
Corn	a	2,463	Wheat	4.88 ±0.06	4.75	5.00	Yes	Yes
Corn	b	2,519	Wheat	4.88 ± .06	4.70	4.98	Yes	Yes
Corn	c	2,487	Wheat	4.93 ± .09	4.71	5.12	Yes	Yes
Soybeans	a	2,521	Screenings	5.30 ± .08	5.14	5.44	Yes	Yes
Soybeans	b	2,515	Screenings	5.28 ± .08	5.07	5.40	Yes	Yes
Soybeans	c	2,504	Screenings	5.25 ± .09	5.05	5.41	Yes	Yes
4-WAY								
Wheat	a	2,545	Corn	4.82 ± .22	4.16	5.38	Yes	Yes
Wheat	b	2,525	Corn	5.07 ± .23	4.68	5.57	Yes	Yes
Wheat	c	2,503	Corn	5.05 ± .19	4.65	5.45	Yes	Yes
Wheat	a	2,545	Screenings	5.50 ± .36	4.45	5.99	No	No
Wheat	b	2,525	Screenings	5.47 ± .53	3.76	6.26	Yes	No
Wheat	c	2,503	Screenings	4.55 ± .40	4.02	5.85	No	No
Corn	a	2,480	Wheat	6.41 ± .24	5.70	6.85	No	Yes
Corn	b	2,475	Wheat	6.20 ± .58	4.03	7.17	No	No
Corn	c	2,516	Wheat	3.86 ± .75	3.01	6.64	No	No
Soybeans	a	2,576	Screenings	4.71 ± .19	4.34	5.18	Yes	Yes
Soybeans	b	2,552	Screenings	5.09 ± .24	4.42	5.60	Yes	Yes
Soybeans	c	2,426	Screenings	4.98 ± .20	4.58	5.53	Yes	Yes

[1] Average of 10 replications.

[2] Known percent component in the primary sample was 5.0 percent.

[3] Mean and 95 percent confidence interval (C.I.) of the mean, respectively.

TABLE 17.—Summary for wheat lot of sample dividers meeting and not meeting established criteria.

Weight primary sample	Size of feeder orifice	Sample divider[1]							
		Garnet 7-1/2 inch	Garnet 12-inch	Denver 15-inch Vezin	Strand		Boerner	Cargo	4-Way
					60 r.p.m.	120 r.p.m.			
Grams	Inches								
500	1 3/8			No					
500	1 1/2	No	No		No				
1,000	1 3/8			No					
1,000	1 1/2	No	No		No				
2,500	1 3/8			No					
2,500	1 1/2	No	No		No				
5,000	1 3/8			No					
5,000	1 1/2	No	No		No	No			
5,000	2 1/4		No	No	No	No			
10,000	2 1/4		No	No	No	No			
50,000							Yes	Yes	No

[1] Yes indicates all criteria were met; no, one or more of criteria were not met; blank, sampler was not evaluated for that particular condition.

TABLE 18.—Summary for corn lot of sample dividers meeting or not meeting established criteria.

Weight primary sample	Size of feeder orifice	Sample divider[1]					
		Gamet 7-1/2-inch	Gamet 12-inch	Denver 15-inch Vezin	Boerner	Cargo	4-Way
Grams	Inches						
500	1 3/8			No			
500	1 1/2	No	No				
1,000	1 3/8			No			
1,000	1 1/2	No	No				
2,500	1 3/8			No			
2,500	1 1/2	Yes	No				
5,000	1 3/8			No			
5,000	1 1/2	Yes	No				
5,000	2 1/4		No	No			
10,000	2 1/4		No	No			
50,000					Yes	Yes	No

[1] Yes indicates all criteria were met; no, one or more of criteria were not met; blank, sampler was not evaluated for that particular condition.

TABLE 19.—Summary for soybean lot of sample dividers meeting and not meeting established criteria.

Weight primary sample	Size of feeder orifice	Sample divider[1]					
		Gamet 7-1/2-inch	Gamet 12-inch	Denver 15-inch Vezin	Boerner	Cargo	4-Way
Grams	Inches						
500	1 3/8			No			
500	1 1/2	Yes	Yes				
1,000	1 3/8			No			
1,000	1 1/2	Yes	Yes				
2,500	1 3/8			No			
2,500	1 1/2	Yes	Yes				
5,000	1 3/8			No			
5,000	1 1/2	Yes	Yes				
5,000	2 1/4		Yes	No			
10,000	2 1/4		Yes	No			
50,000					Yes	Yes	Yes

[1] Yes indicates all criteria were met; no, one or more of criteria were not met; blank, sampler was not evaluated for that particular condition.

CONCLUSIONS

Based on the data presented in this report, the conclusions are as follows:

1. The wheat lot was the most difficult grain lot to accurately divide. This was followed by the corn and soybean lots.

2. The component corn in the wheat lot was the most difficult component to sample accurately.

3. The larger the primary sample, generally, the more accurate the sample division. This may have been true because of the increase in the weight of the secondary sample that usually accompanied increases in the weight of the primary sample.

4. None of the mechanical-type sample dividers performed satisfactorily under all test conditions.

5. The Boerner and Cargo gravity-type sample dividers performed well in these tests. The 4-Way gravity-type divider accurately sampled only the soybean lot under the conditions of these tests.

6. The test conditions imposed in this study were severe. Grain presented to the samplers was poorly mixed. The samplers would, no doubt, have performed better if challenged with well-mixed grain. However, *any* sampling device will be satisfactory if sampling is done of well-mixed grain. The practical need is for a divider which can sample accurately from grain of an unknown degree of uniformity. The presently available mechanical samplers do not appear to meet this need. More work is needed on the design of mechanical-type sample dividers with the objective of accurately dividing a lot of any grain under a wide range of conditions. Alternatively, *procedures* must be developed for use with presently available samplers to meet this same objective.

APPENDIX

The following calculations were used to determine if criterion No. 2 had been met.

Criterion No. 2 is a measure of maximum allowable dispersion. It can be expressed as the maximum population variance which would allow no more than one observation in 10 (on the average) to deviate more than 0.50 percent from the mean. Since only the *sample* variance is actually known, one may calculate the sample variance that would be exceeded only 5 percent of the time if the population varaince were actually at the specified maximum. Thus, from the defining equation:

$$P[\mu + Z_{.05}\,\sigma \leqslant x \leqslant \mu + Z_{.95}\,\sigma] = 0.90$$

we wish:

$$Z_{.05}\,\sigma \leqslant 0.5$$

or

$$\sigma \leqslant \frac{0.5}{Z_{.05}} = \frac{0.5}{1.645} = 0.304.$$

Since, in general, $s^2 \neq \sigma^2$ we need the value of s^2 not exceeded oftener than 5 percent of the time if $\sigma^2 = (0.304)^2 = 0.092$. This may be obtained from the following:

$$P\left[\frac{s^2}{\sigma^2} \leqslant \chi^2/DF_{.95,9}\right] = 0.95$$

$$P[s^2 \leqslant (\sigma^2)(\chi^2/DF_{.95,9})] = 0.95$$

$$P[s^2 \leqslant (0.092)(1.88)] = 0.95$$

$$P[s^2 \leqslant 0.173] = 0.95.$$

Limits (95 percent confidence) based on the maximum $s^2 = 0.173$ (for 10 observations) would be:

$$\overline{X} \pm t_{.05,9}\, s_{\overline{X}}$$

$$\overline{X} \pm 2.26\sqrt{\frac{0.173}{10}} = \overline{X} \pm 0.29.$$

Thus, any sampler component with 95 percent confidence limits greater than ± 0.29 would imply the 10 percent likelihood of an observation more than 0.5 percent from the true value.